CMEs and Space Weather

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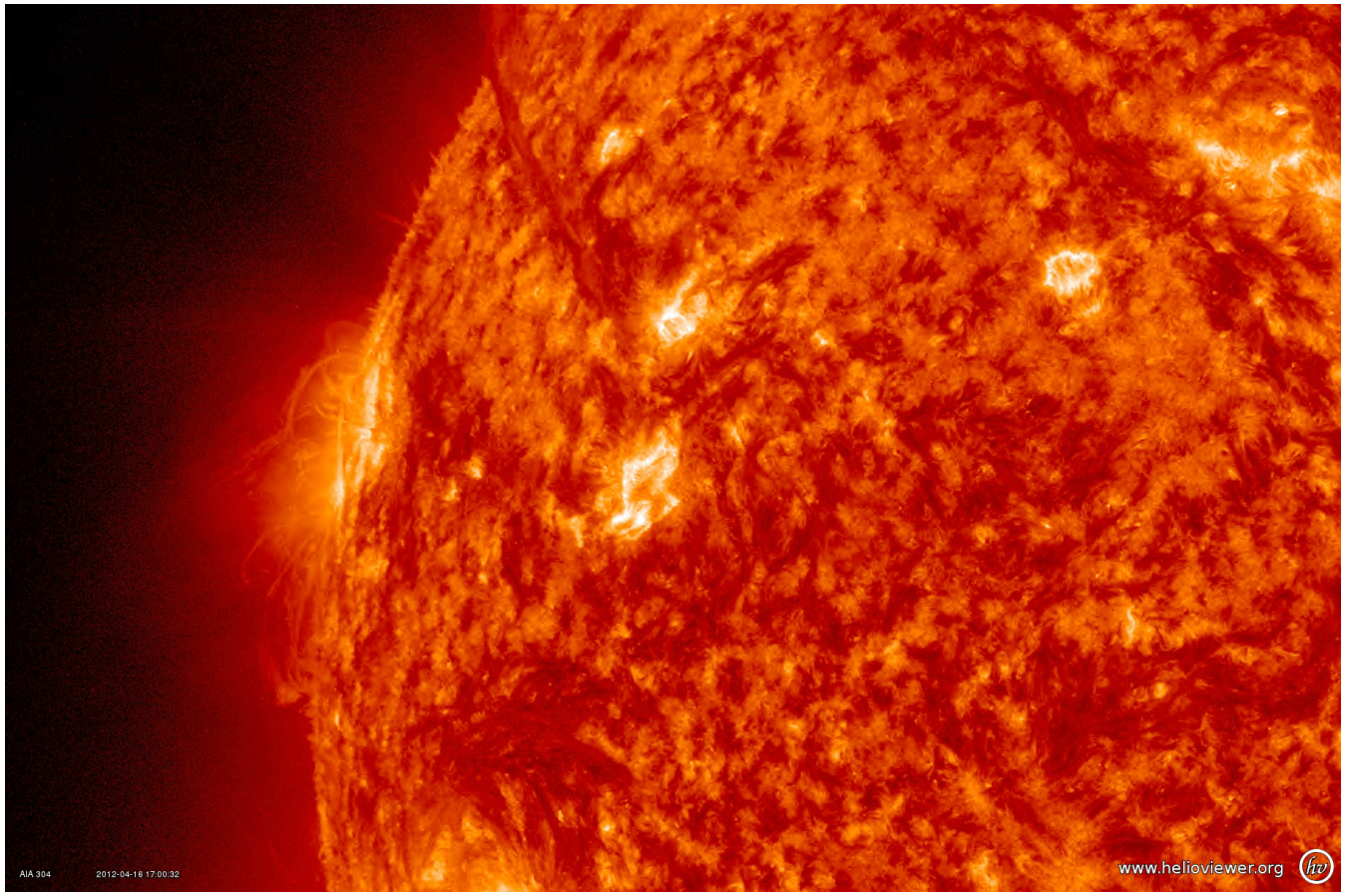
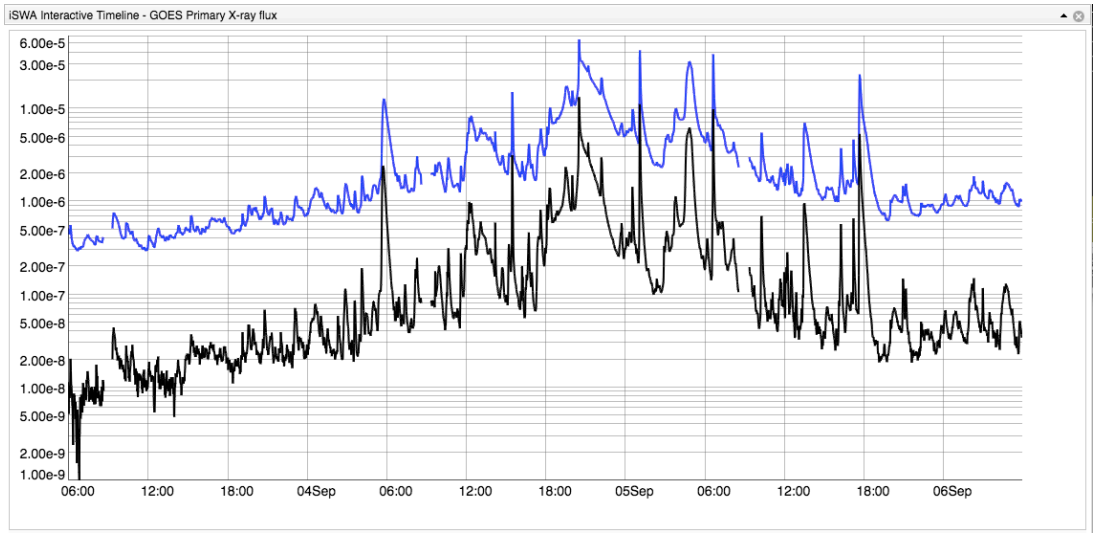
Flares and Coronal Mass Ejections

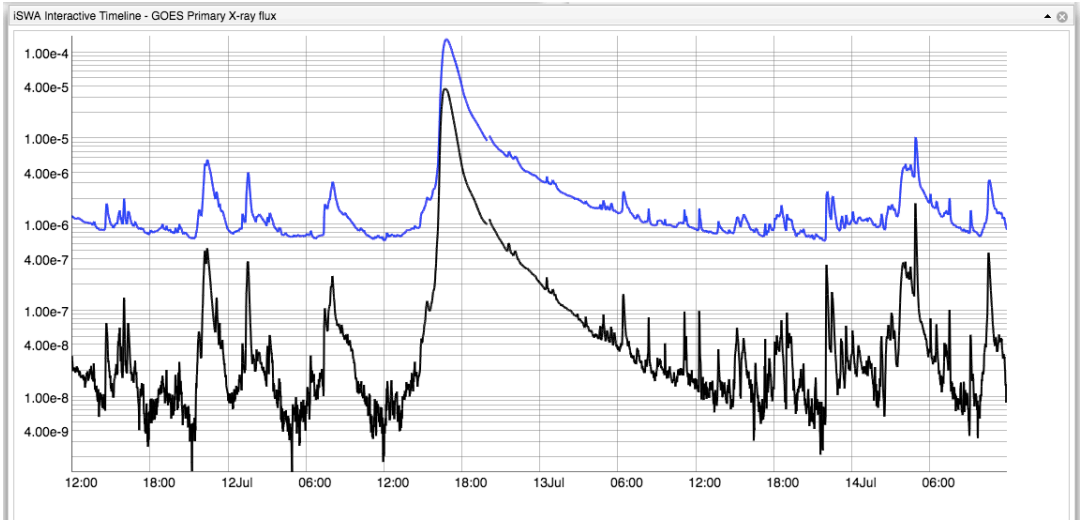
Powerful flares are often accompanied by CMEs in the active regions.



Flares and CMEs – cont.



Short duration flares – no significant eruptions/CMEs

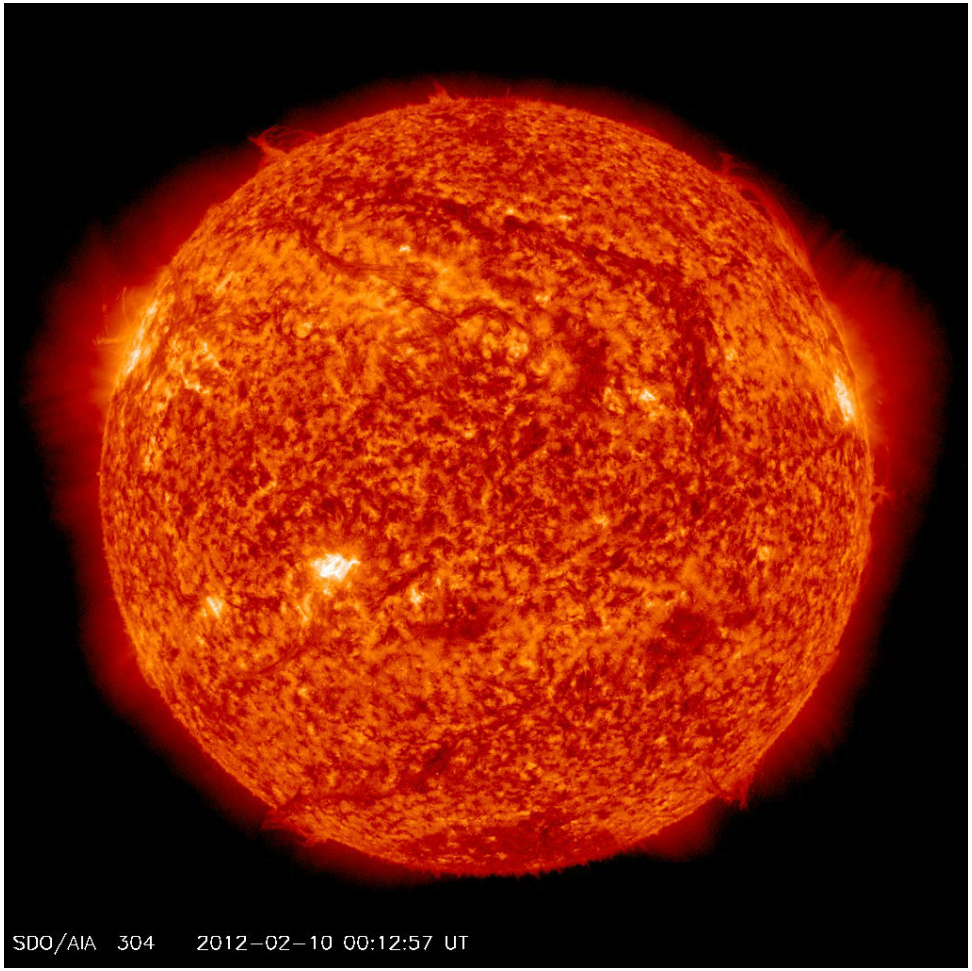


Long duration flare – usually followed by CMEs

Coronal Mass Ejection from a Filament Eruptions

The most energetic CMEs occur in close association with powerful flares in the active regions.

Nevertheless large-scale CMEs do occur in the absence of major flares even though these tend to be slower and less energetic.



CME Properties

- Mass: ~$10^{15\text{-}16}$ g
- Speed: few hundred - 3000km/s

..or

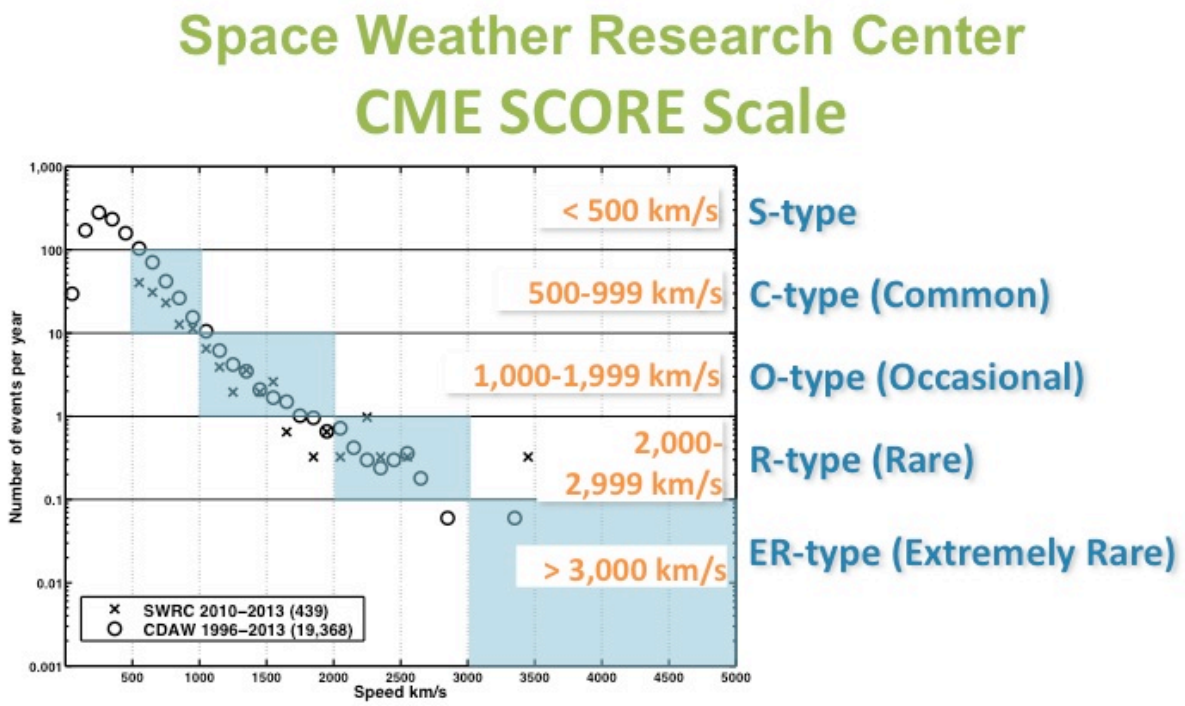
- Mass: ~1 million Nimitz-class aircraft carriers
- Speed: 1.5 -10 million km/hour

Earth?

- Arrives to Earth in 1-2 days

CME score

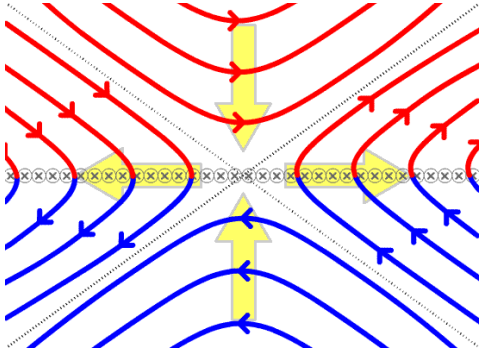
- A new category system for CMEs based on frequency of detection and speed
- Complements Flare Classes
- Applicable in space weather operations and research



Quick quiz

What do you think is causing CME?

CME Mechanism

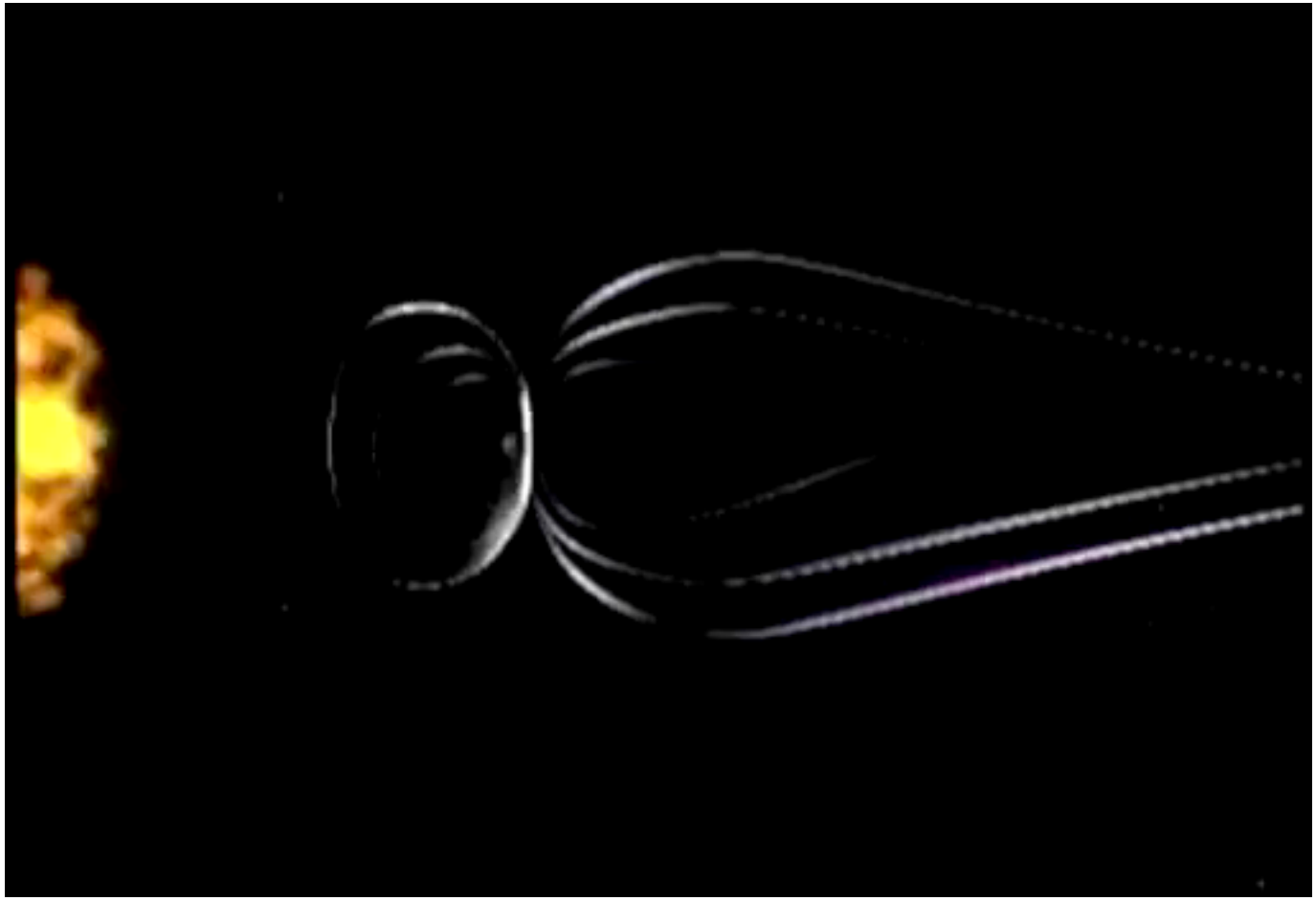


Magnetic Reconnection – the release of free magnetic energy, transformed to heat and particle acceleration

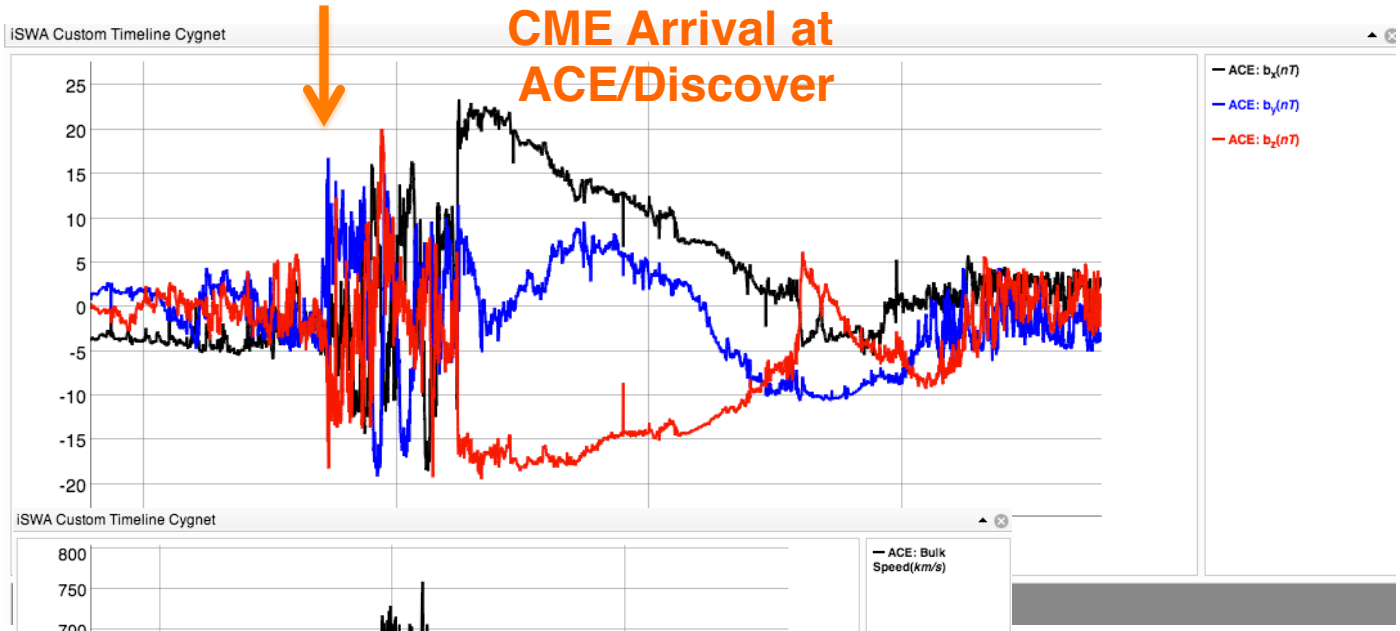
Magnetic field at the base of the convective zone is stressed and pushed to surface due to convection motion

Newly emerged magnetic field interacts with the existing field, reconnection/reconfiguration takes place, leading to heating, flares and eruptions/CMEs

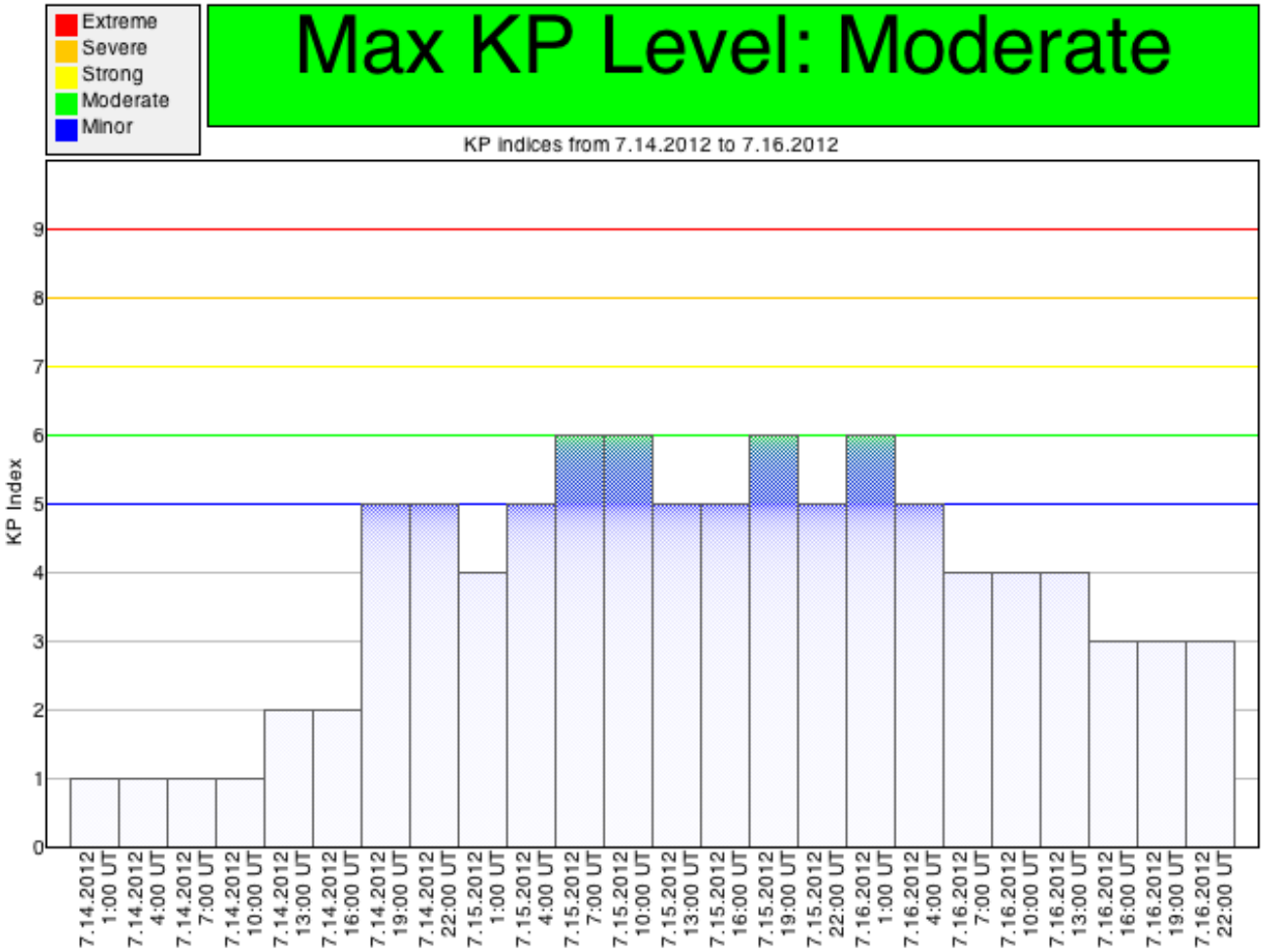
CME Interaction with the Earth's Magnetic Field



CME Arrival at the Earth – Geomagnetic Storms

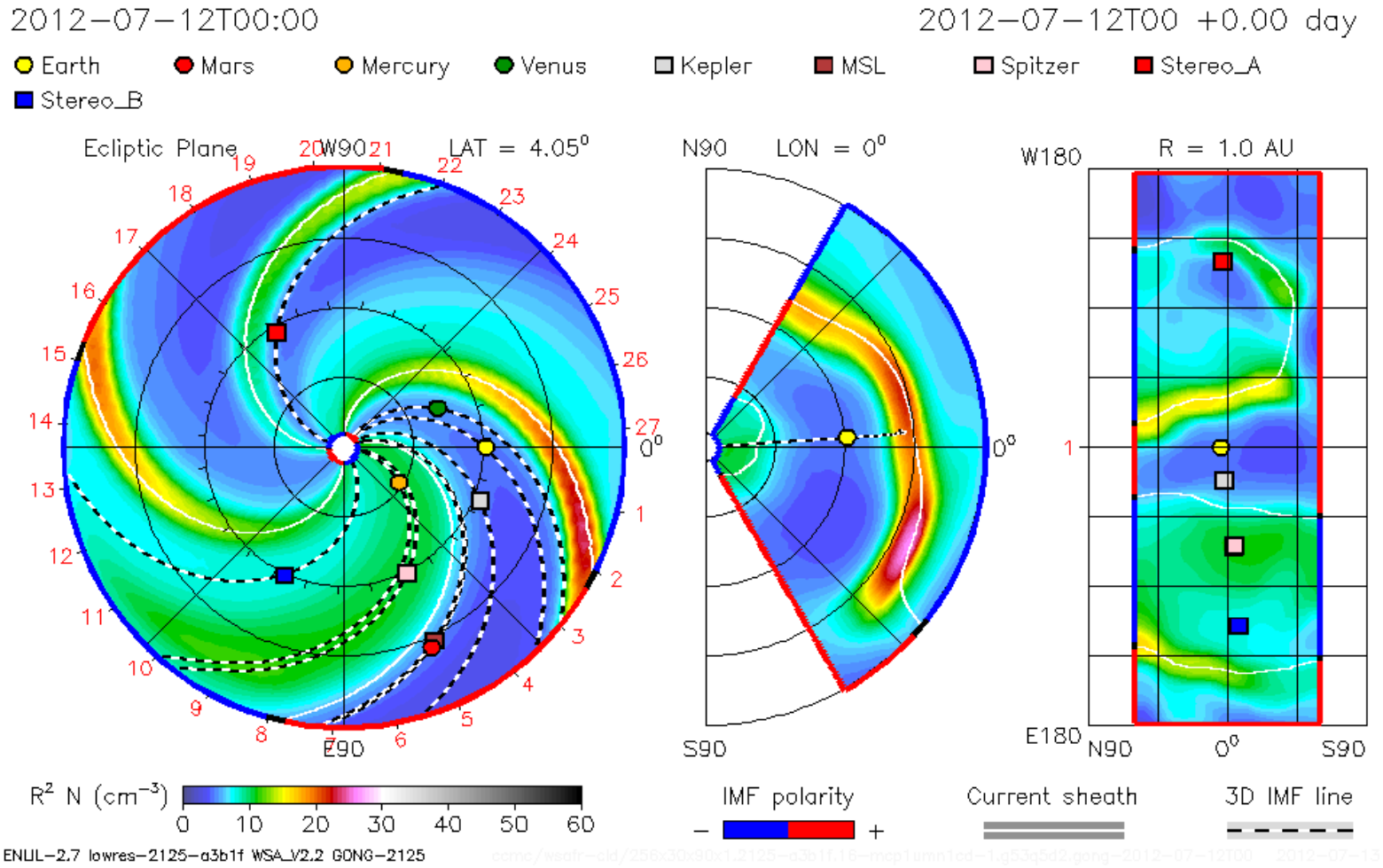


Geomagnetic Storm Kp Index



Kp – index (German “Kennziffer” – characteristic digit)

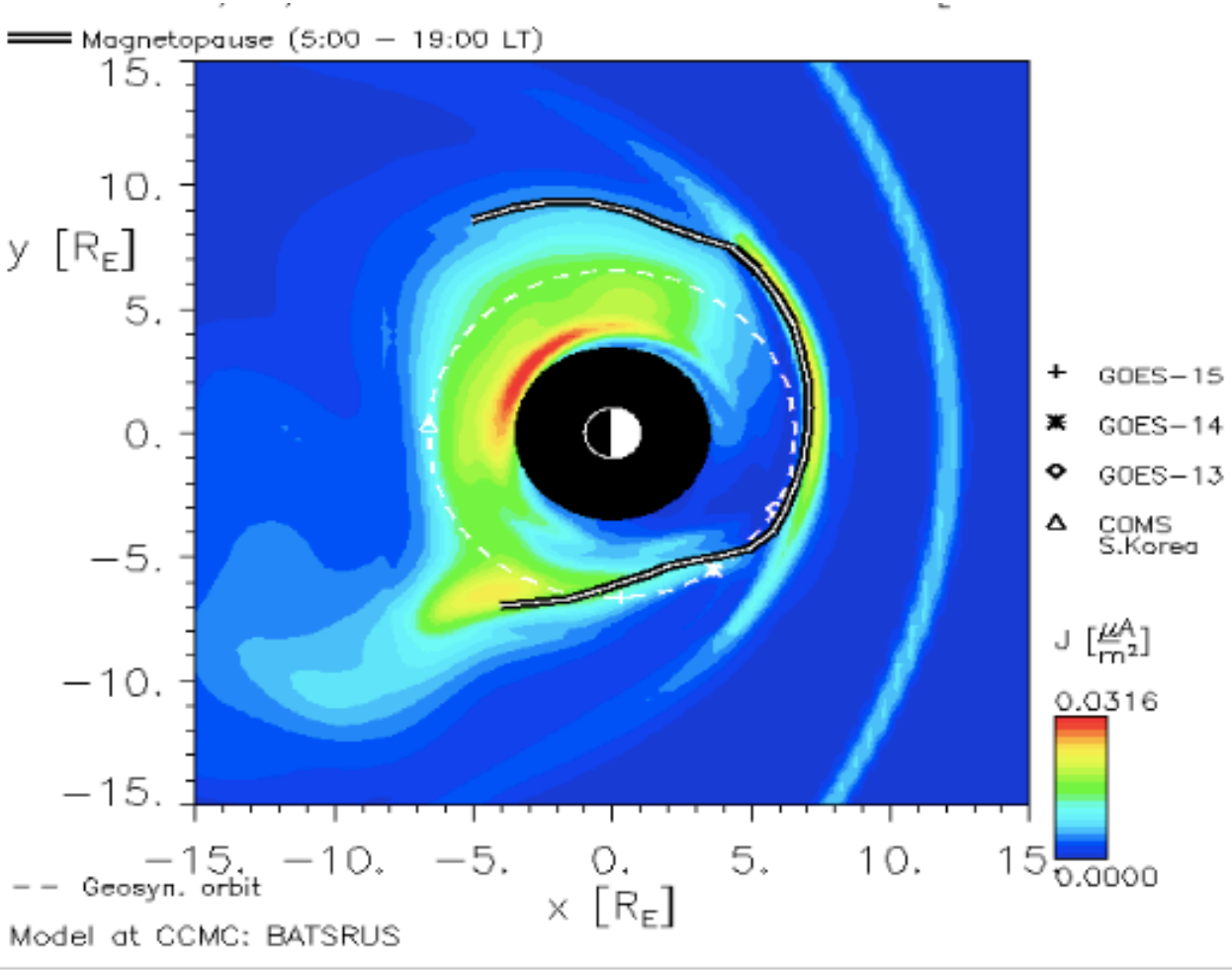
CME Modeling –
Space Weather Storms



Quick Quiz

What physical parameters of CME do you think are important for the strength of the geomagnetic storm?

CME: Space Weather Impacts - Magnetopause Compression



CME: Space Weather Impacts – Geomagnetic Storm, GIC

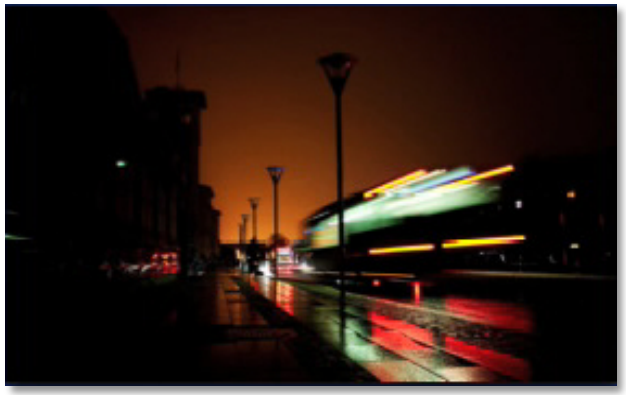
Lasts few hours to 1-2 d after CME arriving at Earth

Geomagnetically Induced currents

Transformer damage saturation

An average CME can dump about 1,500 gigawatts of electricity into Earth's atmosphere—about twice the power-generating capacity of the entire United States!

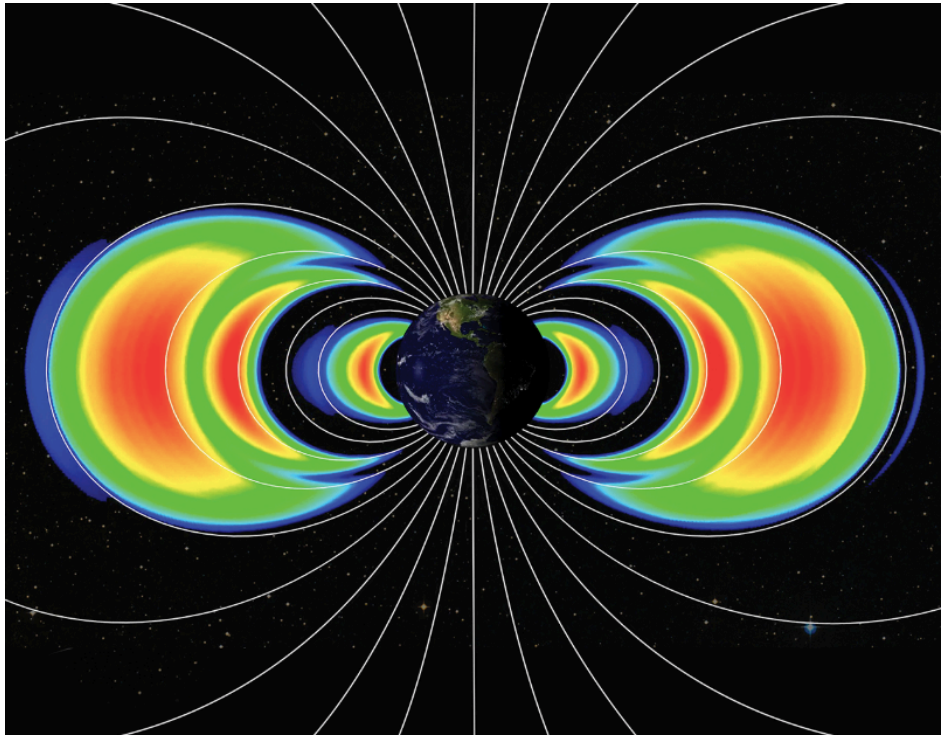
Electric blackout



CME Space Weather Impacts –

Radiation Belts

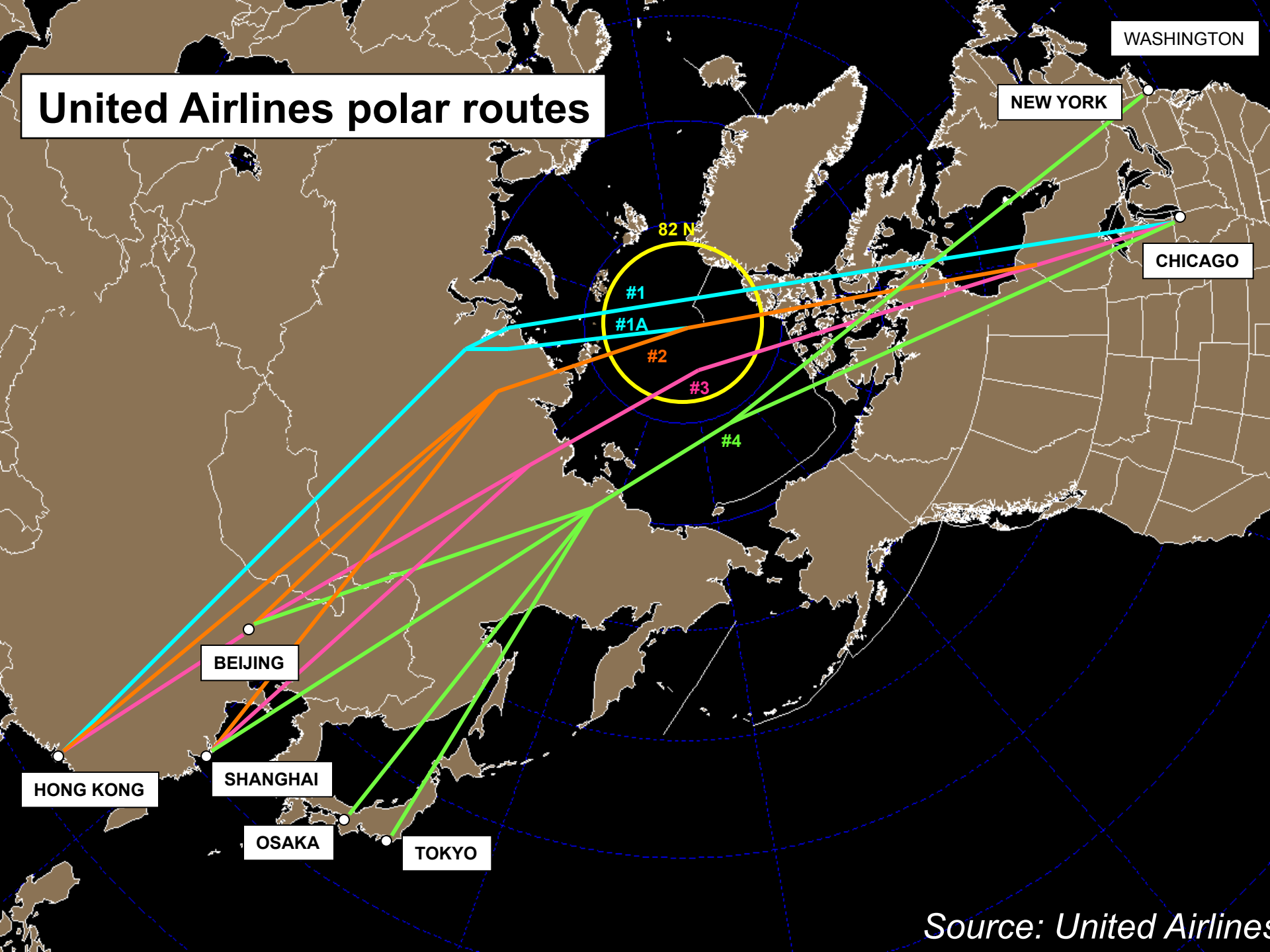
Geomagnetic storms result in electron radiation enhancement in the near-Earth space: lasts 1-3 days



Affecting spacecraft electronics – surface charging/internal charging

CME Space Weather Impacts - SEP

Contributes to SEP (particle radiation): 20-30 minutes from the occurrence of the CME and after the CME arrival


United Airlines polar routes
WASHINGTON
NEW YORK
CHICAGO
82 N
#1
#1A
#2
#3
#4
BEIJING
HONG KONG
SHANGHAI
OSAKA
TOKYO
Source: United Airlines

The END.